JC04 Rec'd PCT/PTO 27 JUN 2001

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		**Attorney's Docket No.** 30990009US **U.S. Application No.** 09/869421 Not Yet Known
International Application No. PCT/GB00/04148	**International Filing Date** 26 October 2000	**Priority Date Claimed** 28 October 1999

Title of Invention:
RATE ADAPTIVE PAYLOAD TRANSMISSION FOR LOCAL AREA NETWORKS

Applicant(s) For DO/EO/US:
Ian JOHNSON et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒: This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a) ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   - b) ☐ has been transmitted by the International Bureau.
   - c) ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report. (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a) ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   - b) ☐ have been transmitted by the International Bureau.
   - c) ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d) ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 13. to 20. below concern other document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A FIRST preliminary amendment.
16. ☐ A SECOND or SUBSEQUENT preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail.
20. ☒ Other items or information
   - a) ☐ Copy of Notification of Missing Requirements.
   - b) ☒ Itemized receipt page
   - c) ☒ Serial number post card.
   - d) ☐ ______________________
   - e) ☐ ______________________
   - f) ☐ ______________________
   - g) ☐ ______________________

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U.S. Application No. 09/869421 Not Yet Known	International Application No. PCT/GB00/04148	Attorney Docket No. 30990009US

21. The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Calculations *PTO USE ONLY*

- ☐ Neither international preliminary examination fee nor international search fee paid to USPTO; International Search Report not prepared by the EPO or JPO — $ 1,000.00
- ☒ International preliminary examination fee not paid to USPTO; International Search Report prepared by EPO OR JPO — $ 860.00
- ☐ International preliminary examination fee not paid to USPTO; international search fee paid to USPTO — $ 710.00
- ☐ International preliminary examination fee paid to USPTO; all claims did not satisfy provisions of PCT Article 33(1)-(4) — $ 690.00
- ☐ International preliminary examination fee paid to USPTO; all claims satisfied provisions of PCT Article 33(1)-(4) — $ 100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =				$860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ **20** ☐ **30** months from the earliest claimed priority date 37 CFR 1.492(e)).				$0.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$0.00	
Total Claims	11 - 20 =	0	x $18.00	$0.00	
Indep. Claims	3 - 3 =	0	x $80.00	$0.00	
Multiple Dependent Claims (if applicable)			$270.00	$0.00	
TOTAL OF ABOVE CALCULATIONS =				$860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28)				$0.00	
SUBTOTAL =				$860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ **20** ☐ **30** months from the earliest claimed priority date (37 CFR 1.492(f).				$0.00	
TOTAL NATIONAL FEE =				$860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31).				$40.00	
TOTAL FEES ENCLOSED =				$900.00	

☐ A check in the amount of $ ___ to cover the above fees is enclosed.

☒ Please charge **Deposit Account No. 08-2025** in the amount of $ **900.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

☒ The Director is hereby authorized to charge any additional fees which may be required, or credit any overpayment to **Deposit Account No. 08-2025**. A duplicate copy of this sheet is enclosed

SEND ALL CORRESPONDENCE TO:

John W. Ryan
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2445 M Street, N.W.
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John W. Ryan, dated June 27, 2001

John W. Ryan, Reg. No. 33,771
202-663-6446
202-663-6363 (facsimile)

09869421 .062701

09/869421
JC03 Rec'd PCT/PTC 27 JUN 2001

In The United States Patent and Trademark Office

Applicant	:	Ian JOHNSON et al.
Appl. No.	:	Not Yet Known
Filed:	:	Herewith
Title	:	RATE ADAPTIVE PAYLOAD TRANSMISSION FOR LOCAL AREA NETWORKS
Grp./A.U.	:	Not Yet Known
Examiner	:	Not Yet Known
Docket No.	:	30990009US

Box Patent Application
Honorable Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir or Madam:

Prior to the examination of the above application, please amend this application as follows:

IN THE CLAIMS:

In accordance with 37 C.F.R. § 1.121(c)(3), please substitute for claims 1, 6 and 11 the following clean version of the claims, in which claims 1, 6 and 11 have been amended. The changes to Claims 1, 6 and 11 are explicitly shown in the attached "Version With Markings To Show Changes Made."

1. **(Once Amended)** A method of communicating over a local area wireless link, said method comprising the steps of:

performing at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitoring for receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitoring a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet has been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceeds a second predetermined number, and said confirmation signal is not received, dropping said data packet.

6. (**<u>Once Amended</u>**) A computer entity capable of communicating over a local area wireless link, said computer entity comprising a transmitter and a receiver wherein said computer entity further comprises:

a processor adapted to control a rate of transmission by the transmitter of a data packet comprising header data and payload data, and to monitor receipt by the receiver of a confirmation signal for confirming that said data packet has been received;

a timer for timing at least one pre-determined time period for monitoring receipt of said confirmation signal;

said computer entity operating to:

perform at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitor receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitor a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet have been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower data rate transmission of said data packet, wherein said

header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceed a second predetermined number, and said confirmation signal is not received, dropping said data packet.

11. <u>**(Once Amended)**</u> A computing entity for communicating over a local area wireless link, said computing entity is configured for receiving a plurality of packet data transmitted over said local area wireless link, said computing entity comprising:

a transmitter;

a receiver adapted to receive a header data of said data packet, at a first data rate;

a decoder adapted to decode a rate field of said header data to obtain a data rate information specifying a data rate at which a payload data of said data packet is to be received, wherein the one is further receiving is adapted to receive said payload data at said specified date rate; and

a processor adapted to verify that said data packet is correctly received; and to generate a confirmation signal confirming receipt of said data packet, and sending said confirmation signal via said transmitter.

REMARKS

Claims 1, 6 and 11 have been amended. Claims 1-11 remain pending in this application. No new matter has been added.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned **Version With Markings To Show Changes Made.**

The examiner is respectfully requested to consider this preliminary amendment prior to examination of the application.

Respectfully submitted,

WILMER, CUTLER & PICKERING

Dated: June 27, 2001

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Version With Markings To Show Changes Made

1. **(Once Amended)** A method of [operating a computer entity for] communicating over a local area wireless link[, said computing entity comprising at least one processor, at least one memory means, at least one transmitter and at least one receiver], said method comprising the steps of:

performing at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitoring for receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitoring a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet [have] has been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceeds a second predetermined number, and said confirmation signal is not received, dropping said data packet.

6. **(Once Amended)** A computer entity capable of communicating over a local area wireless link, said computer entity comprising[: a transmitter

at least one processor;

at least one memory means;]

a [at least one] transmitter[; at least one] and a receiver

wherein said computer entity further comprises:

a processor adapted to control [means for controlling] a [first higher] rate of transmission by the transmitter of a data packet comprising header data and payload data, [for transmission of said header data at a first data transmission rate and transmission of said payload data at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing a transmission data rate of said payload data; means for monitoring] and to monitor receipt by the receiver of a confirmation signal for confirming that said data packet has been received;

[timing means] a timer for timing at least one pre-determined time period for monitoring receipt of said confirmation signal;

said computer entity operating to:

perform at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitor [for] receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitor a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet have been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower data rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceed a second predetermined number, and said confirmation signal is not received, dropping said data packet.

11. **(Once Amended)** A computing entity for communicating over a local area wireless link, said computing entity is configured for receiving a plurality of packet data transmitted over said local area wireless link, said computing entity comprising:

[at least one processor;

at least one memory means;

at least one] a transmitter;

[at least one] a receiver [means, said receiver means operating for receiving] adapted to receive a header data of said data packet, [said header data received] at a first data rate;

a decoder adapted to decode [decoding means for decoding] a rate field of said header data to obtain a data rate information specifying a data rate at which a payload data of said data packet is to be received, [said receiver receiving said payload data at said specified data rate;] wherein the one is further receiving is adapted to receive said payload data at said specified date rate; and

[means for verifying] a processor adapted to verify that said data packet is correctly received; [and] and to generate [means for generating] a confirmation signal confirming receipt of said data packet, and sending said confirmation signal via said transmitter.

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RATE ADAPTIVE PAYLOAD ~~TRANSMISSION~~ FOR LOCAL AREA NETWORKS

Field of the Invention

The present invention relates to local area networks comprising a plurality of node elements communicating with each other by wireless links.

Background to the Invention

Conventional local area networks comprising a plurality of computing entities, for example personal computers (PCs) transmit and receive signals with each other according to known protocols, such as the Ethernet protocol, over coaxial cables connected between Ethernet ports provided at each of the individual computing entities. Whilst cabled network solutions are very successful commercially and technically, they have a disadvantage in flexibility of usage and cost. For example in a typical office environment provision needs to be made for cabling between computing entities, such as raised flooring. Although a cable solution itself is relatively inexpensive, there are hidden costs in provided ducting for cabling between computing entities.

A known solution which removes the need for coaxial cable extending between different computing entities in a local area network involves each computing entity being provided with a transmitter/receiver device which operates at wireless frequencies, typically 5 GHz. Such short range communications are practical within enclosed indoor environments for communicating over short distances of the order of meters to tens of meters at relatively low power. A plurality of computing entities linked together in a local area network use wireless links to communicate with each other. Within a particular network, the plurality of entities all communicate with each other on a single frequency channel, of frequency of the order 5 GHz using a CSMA protocol in which a sending entity transmits a plurality of data packets with all entities in a network receiving the

data packets at the same carrier frequency. The packet contains a header information which includes an address of a particular computing entity for which the packet is intended. The address information is added by a higher level protocol than CSMA. Only the computing entity whose address is included in the header decodes the packet. According to the CSMA protocol, to avoid two or more computing entities transmitting at the same time on a same frequency, the CSMA protocol includes transmission rules which allows or denies each computing entity permission to transmit. Therefore only one computing entity transmits at any one time, and all computing entities receive the transmission, but only computing entities to whom the packet header is addressed decode the packets.

Referring to Fig. 1 herein, there is illustrated schematically first and second computing entities 100, 101 in an indoor office environment communicating with each other. First computing entity 100 comprising a personal computer transmits a message for printing a document, to second computing entity 101, in this example a printer device. In order for the computing entities to be physically moved around relative to each other so that computers, printers, peripheral devices and the like comprising the computing entities in the network can be placed anywhere within a local area, each entity transmits and receives omni-directionally. However, in an indoor environment, such as an office, domestic premises or laboratory there exist a large number of obstacles and reflective surfaces, including walls, heating radiators, doors, ceilings, floorings, filing cabinets and the like, all of which reflect transmissions. Further, the reflective properties of the indoor environment may change dynamically, for example with people walking in and out of the environment, doors or windows opening and closing, new objects being introduced into the area or existing objects being removed from the area.

Receiving entity 101 may receive transmissions from transmitting entity 100 over a large plurality of transmission paths due to reflections in the environment

of the local area network, as illustrated schematically by path arrows 102 – 105 in Fig. 1. Receiving entity 101 receiving multi-path transmission may experience fading due to out-of-phase cancellation from transmissions received over different paths. The problem of fading increases with the rate of data transmission over the network, since inter-symbol interference between received digital pulses increases with increasing data rate, and is also dependent upon the pulse period and the period between the transmission of individual pulses.

Summary of the Invention

Specific implementations of the present invention aim to provide a robust transmission and reception protocol which overcomes or alleviates reception problems caused by multi-path fading and reflections in the transmission environment.

According to first aspect of the present invention there is provided a method of operating a computer entity for communicating over a local area wireless link, said computing entity comprising at least one processor, at least one memory means, at least one transmitter and at least one receiver, said method comprising the steps of:

performing at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitoring for receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitoring a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet have been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceeds a second predetermined number, and said confirmation signal is not received, dropping said data packet.

Said step of performing a higher rate transmission of a data packet may be performed at least two times.

Said step of performing a lower data rate transmission of a data packet may be performed at least twice.

The first pre-determined number may be set at a value of at least two, such that the data packet is sent at the higher data rate transmission at least twice.

The same pre-determined number may be set at a value of at least two, such that the lower data rate transmission is made at least twice prior to dropping the data packet.

The invention includes a computer entity capable of communicating over a local area wireless link, said computer entity comprising at least one processor; at least one memory means; at least one transmitter; at least one receiver; wherein

said computer entity further comprises means for controlling a first higher rate of transmission of a data packet comprising header data and payload data, for transmission of said header data at a first data transmission rate and transmission of said payload data at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing a transmission data rate of said payload data; means for monitoring receipt of a confirmation signal for confirming that said data packet has been received; timing means for timing at least one pre-determined time period for monitoring receipt of said confirmation signal; said computer entity operating to: perform at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data; monitor for receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received; monitor a number of said higher data rate transmissions made; if a number of said higher data rate transmissions of said data packet have been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower data rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate; monitoring a number of said lower data rate transmissions of said data packet; and if a number of said lower data rate transmissions exceed a second predetermined number, and said confirmation signal is not received, dropping said data packet.

The computer entity may further operate such that said step of performing a higher data rate transmission of a data packet is performed at least two times.

The computer entity may further operate such that said step of performing a lower data rate transmission of a data packet is performed at least two times.

The computer entity may be pre-configured such that said first pre-determined number is set at a value of at least two.

The computer entity may be pre-configured such that said second predetermined number is set at a value of at least two.

The invention includes a computing entity for communicating over a local area wireless link, said computing entity is configured for receiving a plurality of packet data transmitted over said local area wireless link, said computing entity comprising: at least one processor; at least one memory means; at least one transmitter; at least one receiver means, said receiver means operating for receiving a header data of said data packet, said header data received at a first data rate; decoding means for decoding a rate field of said header data to obtain a data rate information specifying a data rate at which a payload data of said data packet is to be received, said receiver receiving said payload data at said specified data rate; means for verifying that said data packet is correctly received; and means for generating a confirmation signal confirming receipt of said data packet, and sending said confirmation signal via said transmitter.

Brief Description of the Drawings

For a better understanding of the invention and to show how the same may be carried into effect, there will now be described by way of example only, specific embodiments, methods and processes according to the present invention with reference to the accompanying drawings in which:

Fig. 1 illustrates schematically a local area network comprising a plurality of computing entities communicating with each other over wireless links in a reflective indoor environment;

Fig. 2 illustrates schematically a communications port card component provided for each computing entity, containing a transmitter and receiver for communicating between computing entities according to a specific implementation of the present invention;

Fig. 3 illustrates schematically a data packet transmitted and received between computing entities in a local area network according to the specific implementation of the present invention;

Fig. 4 illustrates schematically a transmission mode process implemented by a processor of the port card for implementing a transmission and reception protocol according to the specific implementation of the present invention;

Fig. 5 illustrates schematically a reception mode process carried out by the specific embodiment of the present invention for handling receipt of packet data and confirming receipt of packet data to a transmitting entity according to the specific implementation of the present invention;

Fig. 6 herein illustrates schematically a successfully transmission of a multi-data rate packet between transmitting and receiving entities in a local area network according to a specific method of the present invention;

Fig. 7 illustrates schematically a successful retransmission of a multi-data rate packet between transmitting and receiving entities according to the specific method of the present invention;

Fig. 8 illustrates schematically a failed transmission and retransmission and successful third transmission of a multi-data rate packet between a transmitting entity and a receiving entity according to the specific method of the present invention; and

Fig. 9 illustrates schematically an unsuccessful communication of a multi-data rate packet on first, second and third attempts between a transmitting entity and a receiving entity, followed by a successful communication of a packet data having a lower payload data rate and confirmation of successful receipt of the packet by the receiving entity according to the specific method of the present invention.

Detailed Description of the Best Mode for Carrying Out the Invention

There will now be described by way of example the best mode contemplated by the inventors for carrying out the invention. In the following description numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent however, to one skilled in the art, that the present invention may be practiced without limitation to these specific details. In other instances, well known methods and structures have not been described in detail so as not to unnecessarily obscure the present invention.

In this specification, the term "local area network" is used to describe a plurality of computing entities which are interconnected to communicate with each other over a local area. The geographical extent of a local area can range from the order of a few meters to a few tens of meters. In the best mode implementation described herein, wireless links are designed and optimized to operate over distances of around 10 meters between transmitting and receiving computer entities.

Referring to Fig. 2 herein there is illustrated schematically a transmitter – receiver port card suitable for use in each computing entity of the network for communicating between entities. The card comprises a super heterodyne architecture transmitter and receiver element 200 for transmitting and receiving signals at a nominal center frequency of 5.86 GHz, with intermediate frequencies

at 1490 MHz and 70 MHz. The transmitter applies modulation to the 1490 MHz intermediate frequency for transmitting bit pulses. It will be understood by those skilled in the art that those frequencies applied in this case is a specific implementation and in the general case, these frequencies may be varied. The port card comprises a dipole antenna for transmission and reception at the operating frequency. On a transmission path, there is provided a formatter circuit 201 which appends a header data to each of a plurality of packets of data prior to transmission and scrambles the data by combining the data with a maximal length sequence. The formatter circuit 201 receives payload data from a micro-processor 202. A header data is pre-pended to each payload data to form a corresponding representative packet. Micro-processor 202 controls transmission of the packets by controlling the transmitter 200 via transmitter/receiver control circuit 203.

A receive circuit comprises the receiver 200, which inputs received RF data to a clock recovery circuit 204. Starter frame detection circuit 206 forms packet synchronization by comparing the header data of received data packets with a stored reference sequence of data. A packet is deemed to have arrived if a detected sequence of 32 bits exactly matches the referenced sequence. Once the packet has been detected, a length field comprising the header data of the packet is read so that a position of the end of the packet can be determined. This information is passed to processor 202 so that the packet can be processed for a cyclical redundancy check (CRC).

Control circuit 203 passes control signals to the transmitter/receiver 200 which includes control signals to switch the transmitter/receiver between receive and transmit modes. With the exception of the clock recovery circuit 205 which operates at 100 MHz, the rest of the circuit operates at 10 MHz, this being compatible with the highest data rate.

The transmitter and receiver elements of the port card of Fig. 2 are designed to operate at a carrier frequency suitable for indoor usage, for example 5 GHz or thereabouts. All computer entities within a network have port cards which operate at the same carrier frequency and transmission of messages by each computer entity is controlled according to a known access control protocol, for example the known CSMA protocol. Data transmission rates are selected such that in normal usage an average data transmission rate between computing entities is sufficiently high to carry continuous data over a transmission link, taking account of any interruptions in transmission and reception which may occur as a result of lost data due to multi-path fading at higher data rates, interruptions in transmission paths due to passage of obstacles, movement of people and the like in the environment in which the network operates. For example where video data is transmitted at 1.5 MBits/s then the average design data rate over a prolonged period must be greater than 1.5 MBits/s in order to carry this traffic. In the best mode implementation, transmission of packetized data is made at a plurality of data rates, which may be above and below the average design data rate over which a link must operate. When conditions of poor transmission are encountered at a higher data rate, a transmitting entity automatically lowers the rate of data transmission to a rate at which reception of the transmission is more likely to be successful. Transmission between computing entities is made by means of a plurality of packets transmitted by a transmitting entity for reception by a receiving entity. Upon successful receipt of a packet by the receiving entity, the receiving entity transmits a confirmation signal back to the transmitting entity, so that the transmitting entity is able to determine that the packet has been successfully received over the wireless link.

Referring to Fig. 3 herein, there is illustrated schematically a single data packet used for transmission over the wireless link. The packet comprises a header portion 300 containing data bytes identifying the intended recipient computing entity of the packet, synchronization data for enabling the receiving entity to synchronize with the packet, and data describing a data rate at which a

remaining payload portion 301 of the packet is about to be transmitted by the transmitting entity. The header portion 300 is always transmitted at a first data rate, which is comparatively low. For example the first data rate may be 1 MBit/s, whereas a second portion of the packet containing payload data can be but is not always transmitted at a second data rate, the second data rate being higher than the first data rate. For example the payload data part of the packet may be transmitted at 10 MBits/s. Alternatively, the transmitter may transmit the payload data portion of the packet at a third data rate, the third data rate being lower than the second data rate. For example in the best mode herein, a first data rate of 1 MBit/s may be used for transmission of the header data, and the second data rate, in the best mode herein 10 MBits/s is used for the payload data. The third data rate, used for a lower payload data rate is 1 Mbits/s.

The first data rate used for transmission of the header portion is selected to be low enough such that under a wide variety of environments, reception by a receiving entity of the network has a high degree of reliability. Selection of the second data rate used for payload transmission, which is higher than the first data rate is selected for optimum data transfer, under normal operating conditions. However, because of reflections and multi-path fading, transmission of the payload data at the higher data rate may not be as reliable as transmission of the header data at the lower data rate. According to the best mode implementation of the present invention, the transmitter attempts to transmit each payload data at a relatively high data rate to obtain as high an overall data rate as possible for data transfer over the wireless link. However, under conditions of fading or poor reception, the transmission entity reverts to a lower payload data rate in order to obtain reliable transmission. A decision on data rate transmission is taken on a per packet basis. That is to say each packet is initially attempted to be transmitted at a higher data rate and if transmission is unsuccessful, the data rate of the payload portion of the packet is reduced to a lower data rate. If the lower data rate transmission is not received within a preset number of attempts, then the packet is dropped. In this specification, the term 'dropping a data

packet' means not attempting to re-transmit the data packet, ceasing to attempt to send the data packet, or ceasing to actually send the data packet. The data packet may become overwritten in an internal memory of a computer entity as a result of dropping the packet. A next packet to be transmitted is again attempted to be transmitted at the higher payload data rate initially, and if the initial transmission is not successfully confirmed by the receiving entity, the payload data portion of the packet is retransmitted at a lower data rate with a predetermined number of attempts. If after a predetermined number of attempts the lower data rate transmission is not successfully confirmed by the receiving entity, the packet is dropped by overwriting it in buffer memory of the port card.

Referring to Fig. 4 of the accompanying drawings, there is illustrated schematically a process carried out by the port card of a transmitting computer entity in a transmit mode. It will be understood by those skilled in the art that the process illustrated in Fig. 4 can be implemented by means of a general purpose processor controlled according to a computer program written in a conventional language implementing an algorithm for performing the process. Alternatively, the process may be carried out by the port card 200 implemented as a dedicated firmware implementation, the design details of which and the general implementation will be apparent to those skilled in the art.

In step 400, a transmitting computing entity transmits a first packet to a receiving entity. The header portion of the packet is transmitted at the first, lower data rate, in the best mode implementation being 1 MBit/s. The header portion contains a field comprising a byte of data, which indicates a data rate at which the remaining payload portion of the packet will be transmitted. The remaining payload portion of the data packet is transmitted at a second, higher rate, in the best mode implementation herein being 10 MBits/s. The transmitting entity then waits in a first predetermined period step 401 until a response is received from the receiving entity. If a response signal is received from the receiving entity confirming that the packet has been successfully received, at the higher data

rate, then the transmitting entity inputs a next packet of the transmission and repeats step 400. However, if after a first predetermined period a confirmation response signal has not been received from the receiving entity, then in step 402 the transmitting entity proceeds to retransmit the data packet in the same manner as in step 400,. That is to say the header data is transmitted at the first, lower data rate and the payload portion of the packet is transmitted at the second, higher data rate. The header portion of the packet contains the same information as previously concerning the data transmission rate of the second portion of the packet. The packet re-transmitted is an exact retransmission of the original packet sent in step 400. The transmitting entity then waits for a confirmation response signal to be received from the receiving entity confirming that the packet has been received. If the transmitting entity receives the confirmation signal from the receiving entity, then the transmitting entity selects a new packet comprising the transmission and reverts to step 400 for transmission of a new packet. However, if after a second predetermined period the transmitting entity has not received a confirmation response signal from the receiving entity indicating that the transmission has failed, then the transmitting entity in step 404 retransmits the packet in the same manner as previously, that is to say transmission of the header data at the lower data rate, and transmission of the payload data at the higher data rate. In step 405, again, the transmitting entity awaits receipt of a confirmation signal from the receiving entity. If the confirmation signal is received within a third predetermined period, then the transmitting entity proceeds to step 400 selecting the next packet in the transmission to be transmitted and proceeds to transmit the next packet. However, if after the third predetermined period there is no confirmation signal from the receiving entity that the packet has been received, the transmitting entity has now attempted three times to transmit the packet at the higher data rate for the payload portion of the packet and has failed. Therefore, in step 406 the transmitting entity switches the payload data rate of the packet to a lower data rate and transmits the packet with the header portion at the first, lower data rate and the payload packet at a third data rate, the third data rate being lower than

the second data rate. The rate of transmission of the payload portion of the packet may be the same as the rate of transmission of the header portion, or may be a third data rate between the data rate of the header portion and the higher data rate of the payload portion of the packet. For example in the best mode implementation where only two data rates are present, say for example 1 MBit/s and 10 MBits/s, in step 406 the whole of the packet will be re-transmitted at the lower data rate. However, in an implementation where more than 2 data rates are used, for example a first data rate, eg 1 MBits/s is used for the header portion, and there are a selection of data rates used for the payload portion, say for example 10 MBits/s and 5 MBits/s, then the packet may be transmitted with a header portion at 1 MBits/s followed by the payload portion transmitted at a third data rate of 5 MBits/s.

In step 407, the transmitting entity waits for a fourth predetermined period, during which receipt of a confirmation signal from the receiving entity is expected. If, within the fourth predetermined period, a confirmation signal is received from the receiving entity, indicating that the packet has been received, then the transmitting entity reverts to step 400 for transmission of the next packet. However, if after the fourth predetermined period confirmation has not been received in step 408 it is checked whether a predetermined number of transmissions of the lower data rate payload packet in step 406 have been achieved. The predetermined number of re-transmissions at the lower payload data rate is preprogrammed and optimized by carrying out trials and experimentation in user environments to determine an optimum number of retries. If the second predetermined number of retransmissions has not been achieved in step 408, then the packet is retransmitted at the lower data rate(s) in step 406. However, if the predetermined number of transmissions have been made, then in step 409 the packet is dropped by overwriting the packet in memory. If the algorithm reaches step 409, then transmission has failed at both the higher (second) payload data rate and the lower (first and/or third) payload data rates.

In Fig. 5, at the receiving entity the port card operates in a receiving mode according to a second algorithm. In step 500, the receiver receives a packet header at a low data rate. In step 501, the port card of the receiving computer entity decodes the header and examines the data rate field to determine the transmission rate of the remaining payload of the packet which is to be received. In step 502, if the data rate information decoded in step 501 indicates that the remainder of the payload data is to be transmitted at a higher data rate, the port card reconfigures itself to receive payload data at the higher rate by adjusting its synchronization to receive higher rate data. However, if the header field decoded in step 501 indicates that the data rate is to be the same as the date rate used for transmission of the header, then no further re-synchronization is required in step 502. In step 503, the port card of the receiving entity receives payload data at the specified payload data rate, and stores the payload data in a buffer, ready for passage to a main processor of the receiving computing entity. At this stage, checking of error detection codes and the integrity of the received payload data may occur within the port card, according to known error corrections codes. In step 504, if the payload data has been received and error correction codes have correctly decoded the payload data, the port card transmits a confirmation signal that the packet has been successfully received in step 504. The receiving entity then proceeds to await receipt of a next packet of the transmission in step 500 and procedure repeats as described hereinabove.

Referring to Fig. 6 herein, there is illustrated a set of transmissions between transmitting entity 600 and receiving entity 601 where no multi-path fading occurs and transmission of the higher data rate payload packet occurs successfully first time. Transmitting entity transmits the low header data rate, high payload data rate packet in step 602 which is successfully received by receiving entity 601. Receiving entity 601 transmits a confirmation signal 603 which is received by transmitting entity 600. Having been successfully transmitted and receipt being

confirmed by the receiving entity, the transmitting entity proceeds to transmit a next packet.

Referring to Fig. 7 herein, there is illustrated schematically transmission between transmitting entity 700 and receiving entity 701 where a low data rate, header, high payload data rate packet is unsuccessfully received on first transmission. In step 702, the transmission entity transmits the data packet having low header rate and high payload data rate. However, the packet is unsuccessfully received by receiving entity 701 on the first transmission. Therefore after the first predetermined period, transmitting entity 700 retransmits the packet having low header data rate and high payload data rate in transmission 703. Transmission 703 is successfully received by receiving entity 701 which generates a confirmation signal 704 which is transmitted back to the transmitting entity 700.

Referring to Fig. 8 herein, there is illustrated schematically transmissions between transmitting entity 800 and receiving entity 801 where a data packet having low header data rate and high payload data rate is successfully received upon its third transmission, the first two transmissions 802, 803 of the packet being lost. On the third transmission of the packet 804, the packet is successfully received by receiving entity 801 which then generates confirmation signal 805 which is retransmitted back to the transmitting entity 800. On receiving the confirmation signal, the transmitting entity then proceeds to transmit a next packet in step 400.

Referring to Fig. 9 herein, there is illustrated schematically a case where transmission of a data packet having a low header data rate and higher payload data rate is unsuccessful after three attempts. Transmissions 902, 903, 904 of the high payload rate packet are made between transmitting entity 900 and receiving entity 901. The transmitting entity, after having received no response from any of the three initial packet transmissions 902 – 904 retransmits the same

packet in transmission 905 having a low data rate header and lower data rate payload at the first or third data rates. The packet is successfully received by receiving entity 901 which generates a confirmation signal 906 which is sent back to transmitting entity 900, upon receipt of which transmitting entity 900 proceeds to select a new packet, transmitting the new packet at the higher payload data rate in step 400.

Practical tests were made on a specific embodiment according to the present invention comprising a pair of port cards each having a transmitter/ receiver operating at a centre frequency of 5.8 GHz. Tests were carried out on tens of thousands of packets in a radio hostile indoor environment. The basic measurement technique was to transmit a series of packets and log information about the detected packets at the receiver. The indoor environment included a laboratory of dimensions 10 metres x 10 metres x 3 metres having a floor and ceiling of metal construction, one wall completely metallic and three walls being partially metallic with glass panels. Measurements indicated a delay spread of signals as high as 45 ns. Measurements were made at a second higher data rate of 10 Mbits/s and at a lower (first or third) data rate of 1 MBit/s. In both cases, a diversity receiver was used. For a typical measurement made over 50,000 received packets, transmitted between transmitter and receiver separated by approximately 7 metres, statistical information on percentage packet detection rate, packet success rate percentage, average received signals strength indicated, average error burst, and a maximum error burst were as follows:

10 MBits/s

Packet detection rate percentage	92.7
Packet success rate percentage	87.2
Average RSSI	142 (-55dBm)
Average error burst	5
Maximum error burst	173

1 MBit/s

Packet detection rate percentage	99.9
Packet success rate percentage	88.9
Average RSSI	148 (-52dBm)
Average error burst	1
Maximum error burst	3

The above results indicate that an improvement in packet detection rate and packet success rate are achieved by switching bit rate from 10 MBits/s to 1 MBit/s in a radio-hostile indoor environment.

For a less hostile environment, representing a typical domestic environment comprising a room in a building made of brick with relatively thick internal and external walls, in a room 8 metres x 12 metres x 2.5 metres, with a same separation of approximately 7 metres between transmitter and receiver, results for the measured parameters at 10 MBits/s and 1 MBit/s were as follows:

10 MBits/s

Packet detection rate percentage	99.2
Packet success rate percentage	98.1
Average RSSI	127 (-62dBm)
Average error burst	3
Maximum error burst	20

1 MBit/s

Packet detection rate percentage	99.9
Packet success rate percentage	98.8
Average RSSI	143 (-55dBm)
Average error burst	1
Maximum error burst	6

In the less hostile environment, the packet success rate and packet detection rate at 10 MBits/s are improved over a hostile environment. However there is still an improvement in packet detection rate and packet success rate to be obtained by switching payload data transmission rate to a lower data rate.

Claims:

1. A method of operating a computer entity for communicating over a local area wireless link, said computing entity comprising at least one processor, at least one memory means, at least one transmitter and at least one receiver, said method comprising the steps of:

performing at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitoring for receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitoring a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet have been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceeds a second predetermined number, and said confirmation signal is not received, dropping said data packet.

2. The method as claimed in claim 1, wherein said step of performing a higher rate transmission of a data packet is performed at least two times.

3. The method as claimed in claim 1, wherein said step of performing a lower data rate transmission of a data packet is performed at least two times.

4. The method as claimed in claim 1, wherein said first predetermined number is set at a value of at least two.

5. The method as claimed in claim 1, wherein said second predetermined number is set at a value of at least two.

6. A computer entity capable of communicating over a local area wireless link, said computer entity comprising:

at least one processor;

at least one memory means;

at least one transmitter;

at least one receiver;

wherein said computer entity further comprises:

means for controlling a first higher rate of transmission of a data packet comprising header data and payload data, for transmission of said header data at a first data transmission rate and transmission of said payload data at a second transmission data rate, said second data rate being higher than said first data

rate, said header data containing a field describing a transmission data rate of said payload data;

means for monitoring receipt of a confirmation signal for confirming that said data packet has been received;

timing means for timing at least one pre-determined time period for monitoring receipt of said confirmation signal;

said computer entity operating to:

perform at least once, a higher data rate transmission of a data packet comprising a header data and a payload data, wherein said header data is transmitted at a first transmission data rate and said payload data is transmitted at a second transmission data rate, said second data rate being higher than said first data rate, said header data containing a field describing said second transmission data rate of said payload data;

monitor for receipt of a confirmation signal, said confirmation signal confirming that said data packet has been received;

monitor a number of said higher data rate transmissions made;

if a number of said higher data rate transmissions of said data packet have been made which exceeds a first predetermined number, and said confirmation signal is not received, then performing at least one lower data rate transmission of said data packet, wherein said header data is transmitted at said first data rate and said packet data is transmitted at a data rate being lower than said second transmission data rate;

monitoring a number of said lower data rate transmissions of said data packet; and

if a number of said lower data rate transmissions exceed a second predetermined number, and said confirmation signal is not received, dropping said data packet.

7. The computer entity as claimed in claim 6, further operating such that said step of performing a higher data rate transmission of a data packet is performed at least two times.

8. The computer entity as claimed in claim 6, further operating such that said step of performing a lower data rate transmission of a data packet is performed at least two times.

9. The computer entity as claimed in claim 6, pre-configured such that said first pre-determined number is set at a value of at least two.

10. The computer entity as claimed in claim 6, pre-configured such that said second predetermined number is set at a value of at least two.

11. A computing entity for communicating over a local area wireless link, said computing entity is configured for receiving a plurality of packet data transmitted over said local area wireless link, said computing entity comprising:

at least one processor;

at least one memory means;

at least one transmitter;

at least one receiver means, said receiver means operating for receiving a header data of said data packet, said header data received at a first data rate;

decoding means for decoding a rate field of said header data to obtain a data rate information specifying a data rate at which a payload data of said data packet is to be received, said receiver receiving said payload data at said specified data rate;

means for verifying that said data packet is correctly received; and

means for generating a confirmation signal confirming receipt of said data packet, and sending said confirmation signal via said transmitter.

Abstract

RATE ADAPTIVE PAYLOAD TRANSMISSION FOR LOCAL AREA NETWORKS

A method of communication between computing entities in a local area network operating an CSMA protocol in an environment where reflections of omni-directional transmissions from a plurality of objects cause multi-path fading includes data packets being transmitted having a header at a first, lower data rate, followed by transmission of payload data at a second, higher data rate. Where the packets are not confirmed to be received, the packet is retransmitted a predetermined number of times before the transmitting entity reduces the payload data rate of the packet and retransmits the packet. If the retransmitted lower payload data rate packet is not confirmed to be received within the predetermined number of transmissions at the lower rate, the packet is dropped.

Fig. 4

09/869421

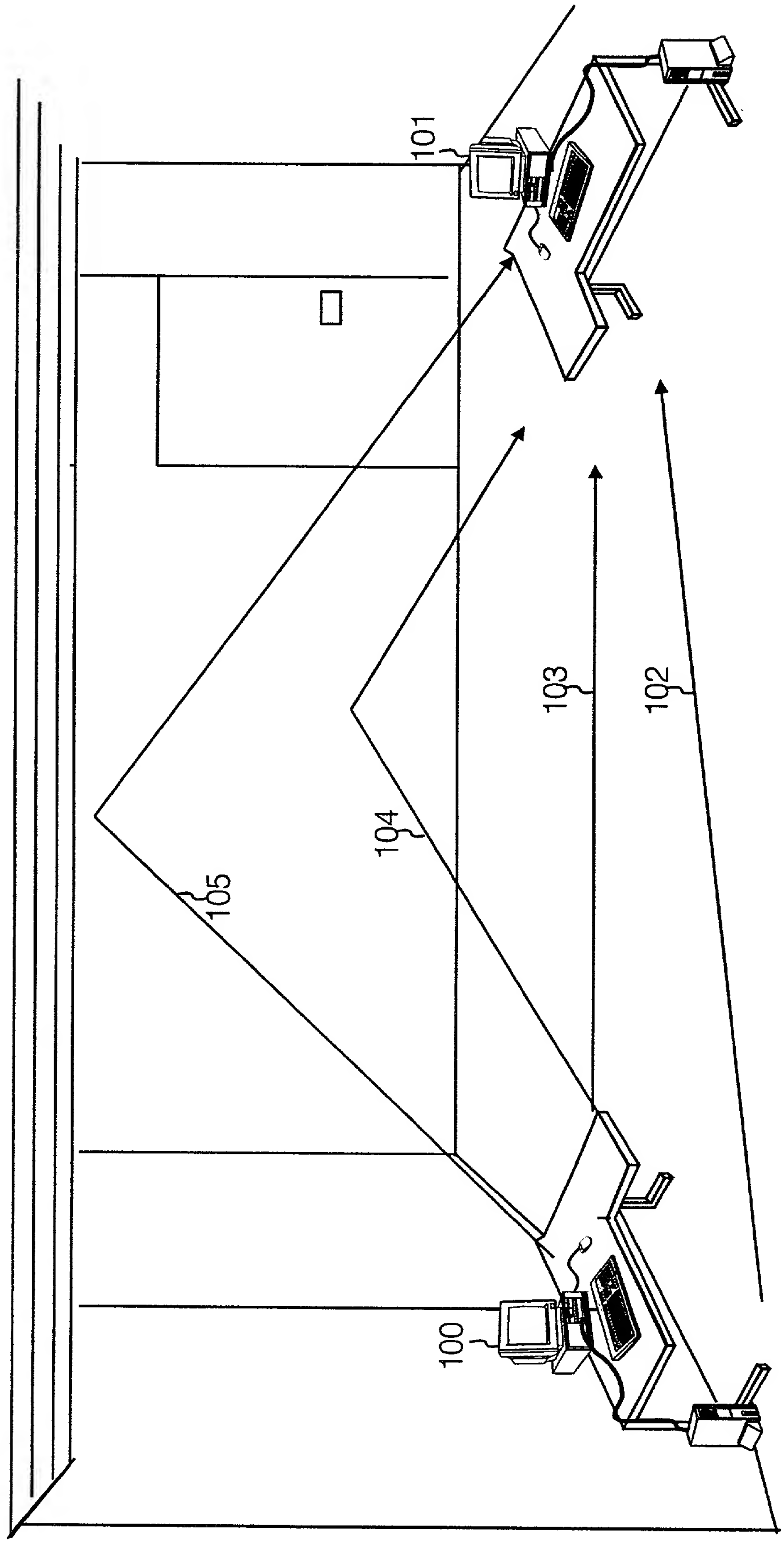


Fig. 1

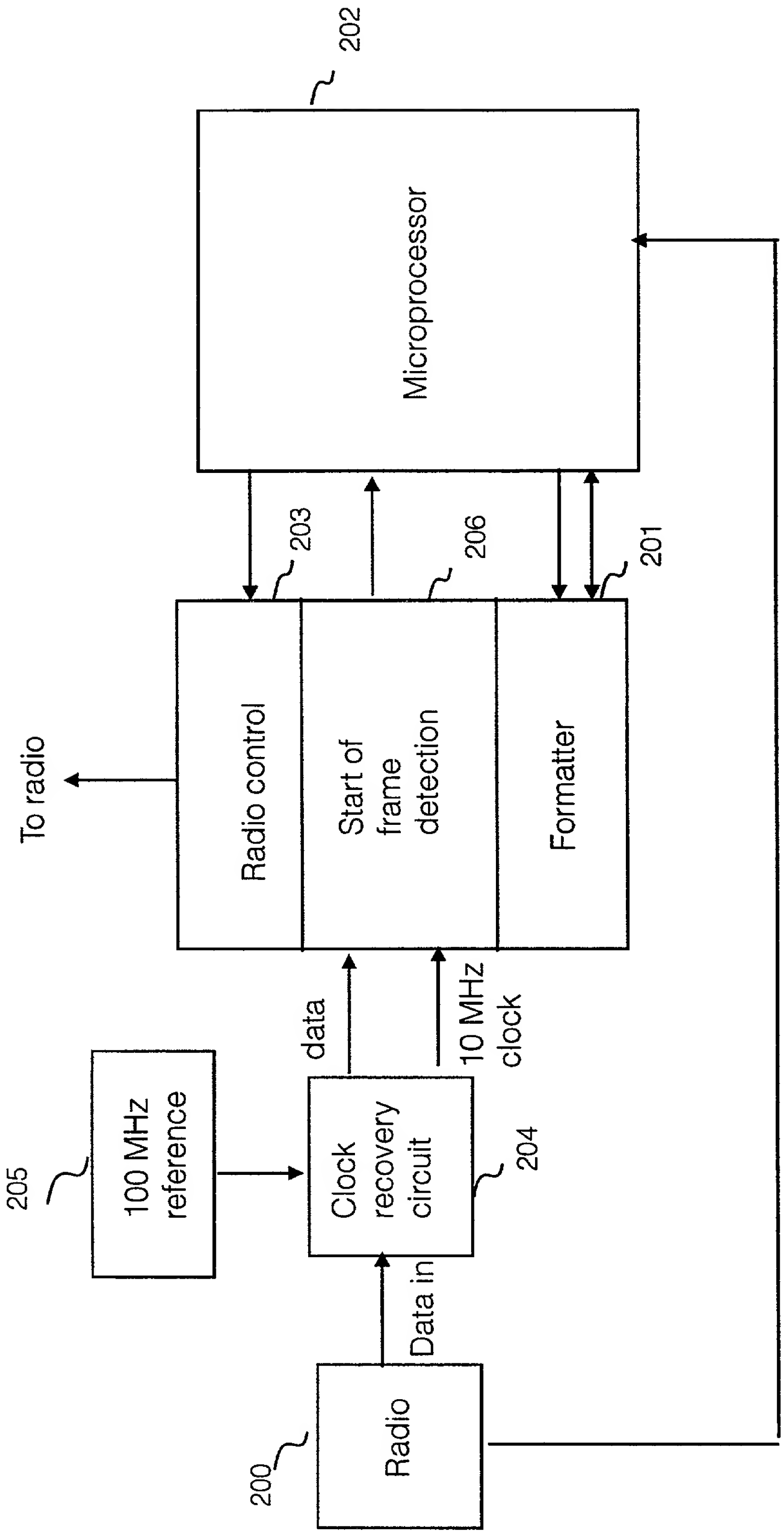

202
Microprocessor
203
206
201
To radio
Radio control
Start of frame detection
Formatter
data
10 MHz clock
205
100 MHz reference
Clock recovery circuit
204
Data in
200
Radio

Fig. 2

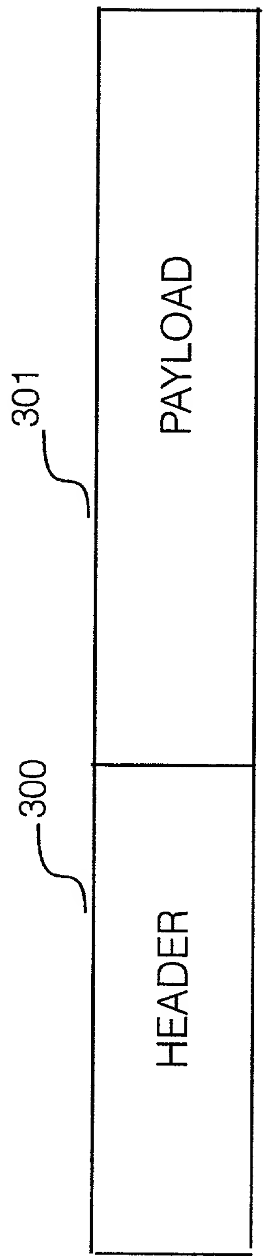


Fig. 3

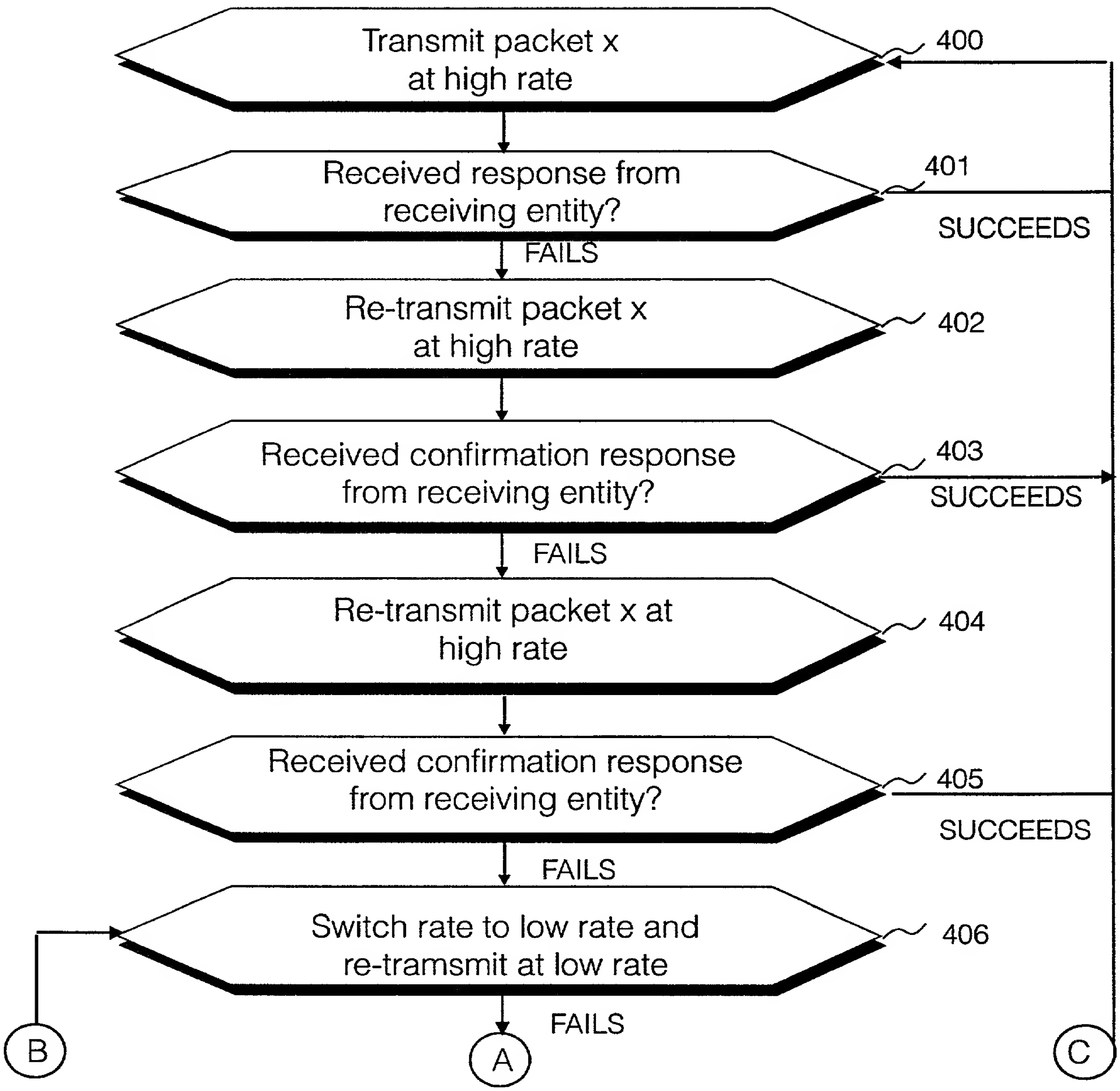

Transmit packet x
at high rate
400
Received response from
receiving entity?
401
SUCCEEDS
FAILS
Re-transmit packet x
at high rate
402
Received confirmation response
from receiving entity?
403
SUCCEEDS
FAILS
Re-transmit packet x at
high rate
404
Received confirmation response
from receiving entity?
405
SUCCEEDS
FAILS
Switch rate to low rate and
re-tramsmit at low rate
406
FAILS
B
A
C

Fig. 4

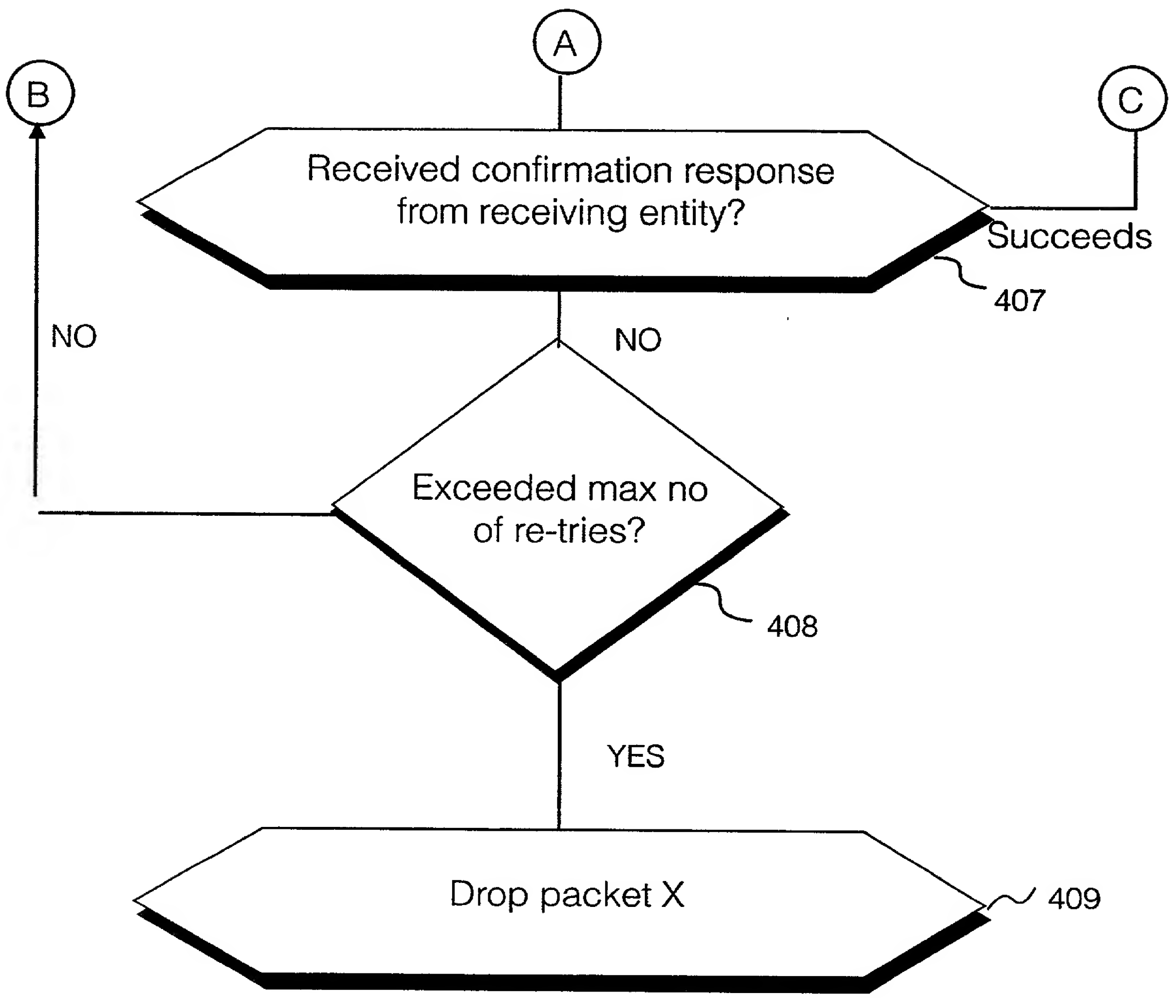
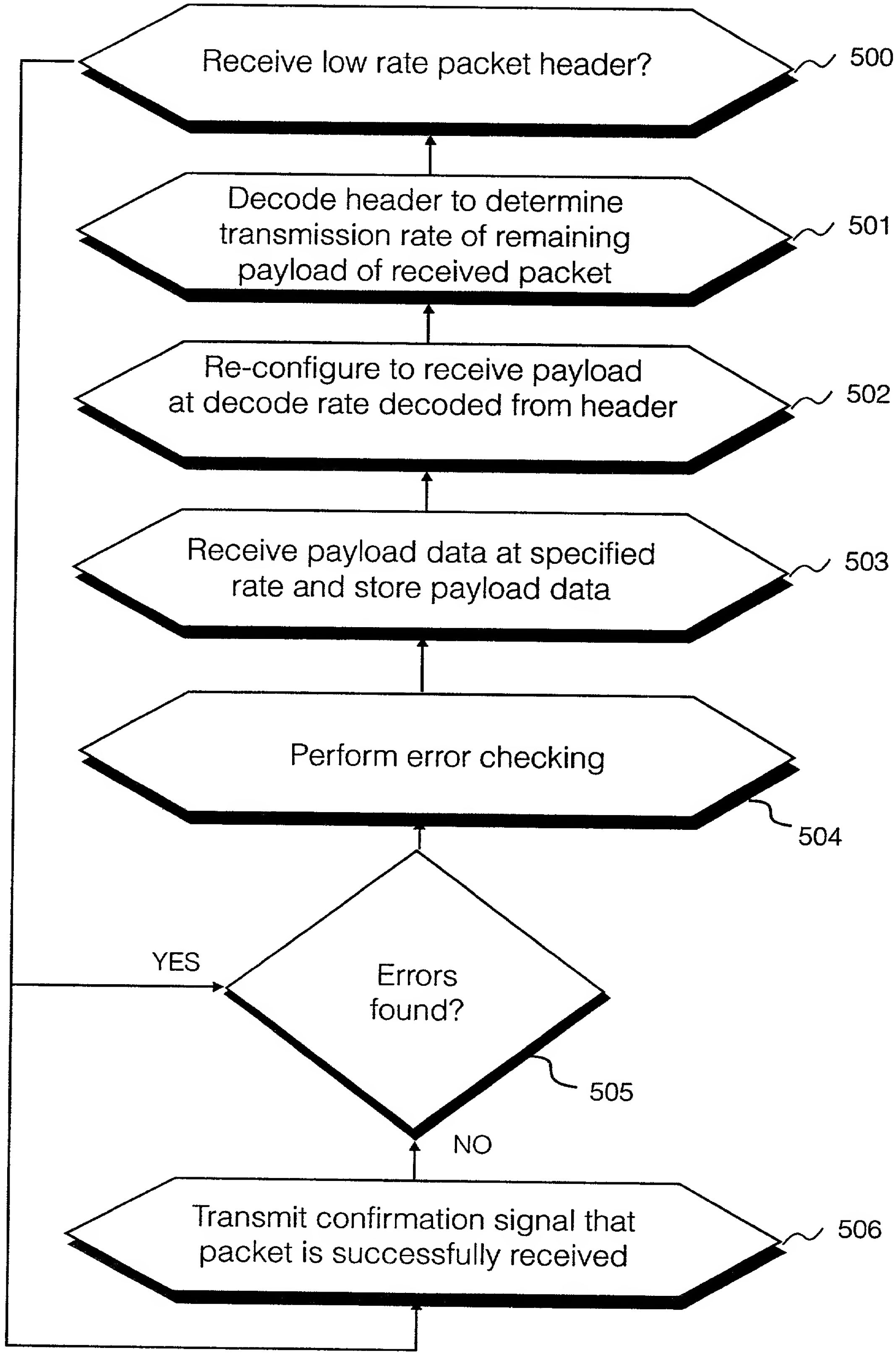

A
B
C
Received confirmation response from receiving entity?
Succeeds
407
NO
NO
Exceeded max no of re-tries?
408
YES
Drop packet X
409

Fig. 4



Receive low rate packet header?
500
Decode header to determine transmission rate of remaining payload of received packet
501
Re-configure to receive payload at decode rate decoded from header
502
Receive payload data at specified rate and store payload data
503
Perform error checking
504
YES
Errors found?
505
NO
Transmit confirmation signal that packet is successfully received
506

Fig. 5

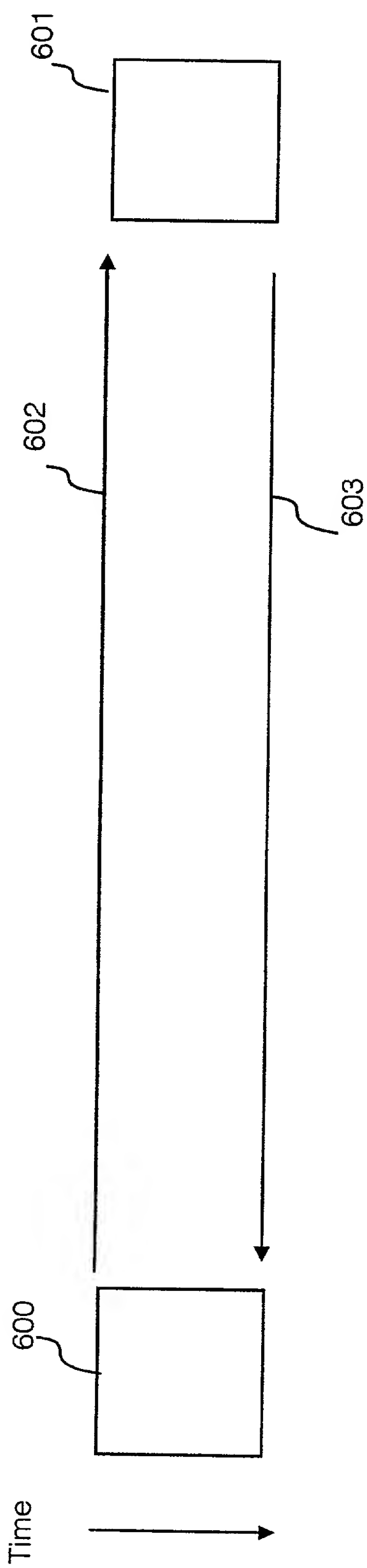


Fig. 6

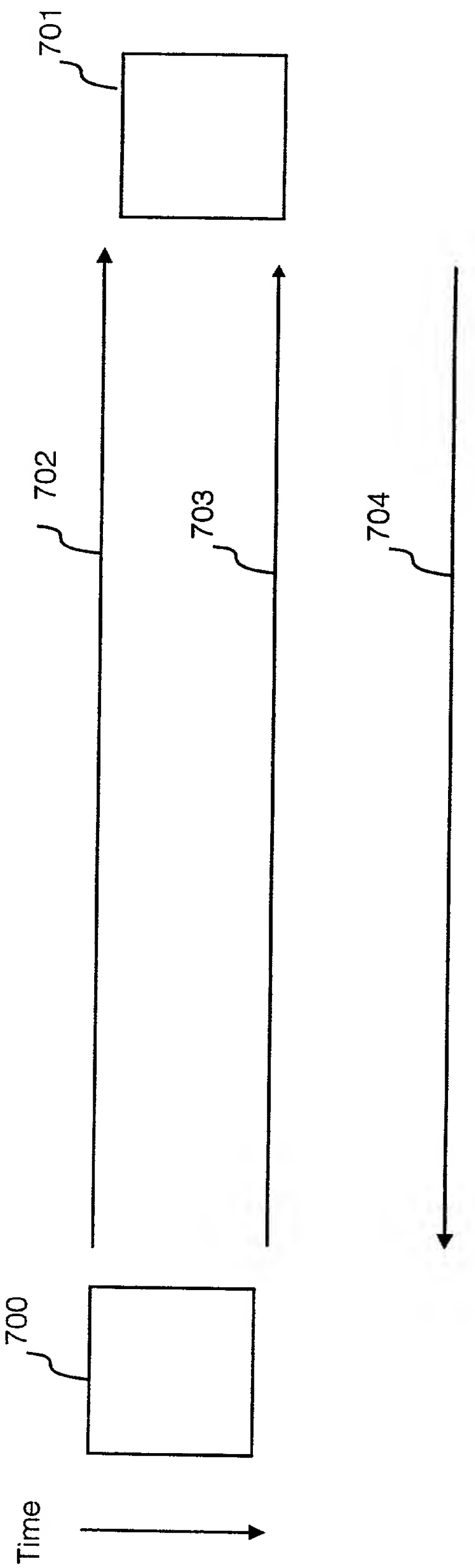


Fig. 7

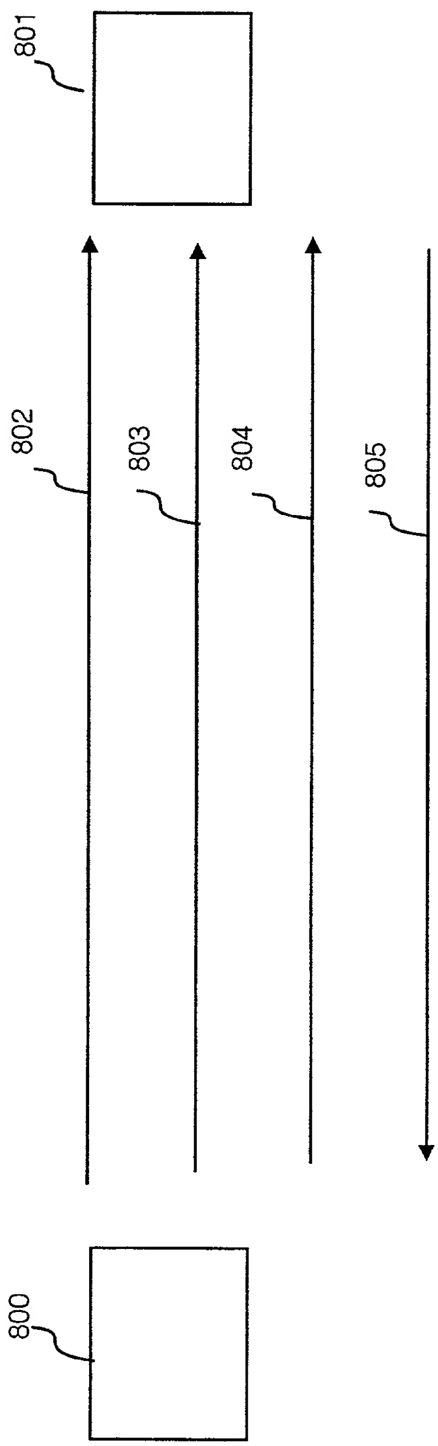


Fig. 8

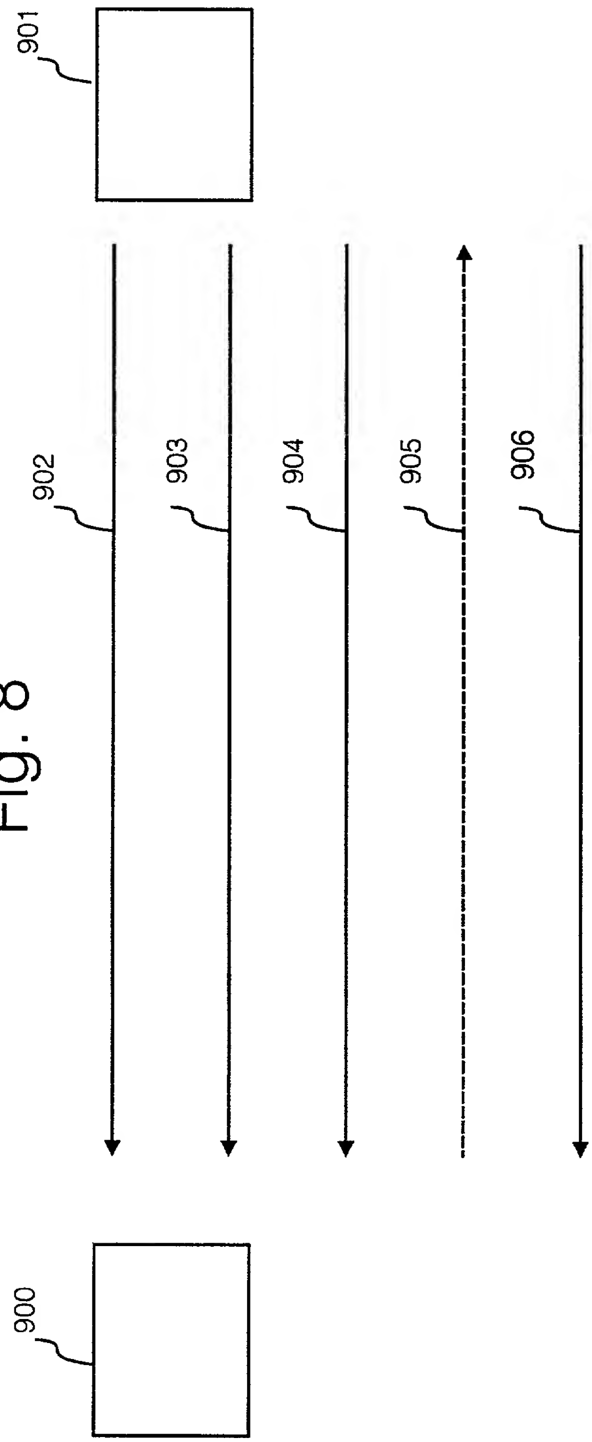


Fig. 9

COMBINED DECLARATION FOR PATENT APPLICATION & POWER OF ATTORNEY DOCKET No. 30990009
(Includes Reference to PCT International Applications)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Rate Adaptive Payload Transmission for Local Area Networks

the specification of which was filed as PCT international application

Number PCT/GB00/04148

on 26 October 2000

and was amended under PCT Article 19

on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code,. 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119	
EP	99308518.2	28 October 1999	X Yes	_ No
			_ Yes	_ No
			_ Yes	_ No

I hereby claim the benefit under Title 35, United States Code,. 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code,. 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

COMBINED DECLARATION FOR PATENT APPLICATION & POWER OF ATTORNEY (Continued)
(Includes Reference to PCT International Applications)

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.		
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

5

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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